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Neutron Stars, Pulsars and Supernova Remnants: concluding remarks F. Pacini1,2 Arcetri Astrophysical Observatory, L.go E. Fermi, 5, I-50125 Firenze,Italy Dept. of Astronomy and Space Science, University of Florence, L.go E. Fermi, 2, I-50125 Firenze, Italy

Introduction

More than 30 years have elapsed since the discovery of pulsars (Hewish *et al.* hew68) and the realization that they are connected with rotating magnetized neutron stars (Gold gold68; Pacini p67, p68). It became soon clear that these objects are responsible for the production of the relativistic wind observed in some Supernovae remnants such as the Crab Nebula.

For many years, the study of pulsars has been carried out mostly in the radio band. However, many recent results have come from observations at much higher frequencies (optical, X-rays, gamma rays). These observations have been decisive in order to establish a realistic demography and have brought a better understanding of the relationship between neutron stars and SN remnants.

The Proceedings of this Conference cover many aspects of this relationship (see also previous Conference Proceedings such as Bandiera *et al.* elba98; Slane and Gaensler, bost02). Because of this reason, my summary will not review all the very interesting results which have been presented here and I shall address briefly just a few issues. The choice of these issues is largely personal: other colleagues may have made a different selection.

Demography of Neutron Stars: the role of the magnetic field For a long time it has been believed that only Crab-like remnants (plerions) contain a neutron star and that the typical field strength of neutron stars is 10^{12} Gauss. The basis of this belief was the lack of pulsars associated with shell-type remnants or other manifestations of a relativistic wind. The justification given is that some SN explosions may blow apart the entire star. Alternatively, the central object may become a black hole. However, the number of shell remnants greatly exceeds that of plerions: it becomes then difficult to invoke the formation of black holes, an event much more rare than the formation of neutron stars.

The suggestion that shell remnants such as Cas A could be associated with neutron stars which have rapidly lost their initial rotational energy because of an ultra-strong magnetic field $B \sim 10^{14} - 10^{15}$ Gauss (Cavaliere & Pacini, cav70) did receive little attention. The observational situation has now changed: a compact thermal X-ray source has been discovered close to the center of Cas A (Tananbaum, tanan99) and it could be the predicted object. Similar sources have been found in association with other remnants and are likely to be neutron stars. We have also heard during this Conference that some shell-type remnants (including Cas A) show evidence for a weak non-thermal X-ray emission superimposed on the thermal one: this may indicate the presence of a residual relativistic wind produced in the center. Another important result has been the discovery of neutron stars with ultra-strong magnetic fields, up to $10^{14} - 10^{15}$ G. In this case the total magnetic energy could be larger than the rotational energy ("magnetars"). This possibility had been suggested long time ago (Woltjer, woltj68). It should be noticed, however, that the slowing down rate determines the strength of the field at the speed of light cylinder and that the usually quoted surface fields assume a dipolar geometry corresponding to a braking index $n = 3$. Unfortunately the value of n has been measured only in a few cases and it ranges between $1.4 - 2.8$ (Lyne *et al.*, lyne96).

The present evidence indicates that neutron stars manifest themselves in different ways: itemize

s the energy source.
in binary systems).
from a hot surface.
lissipated by flares.
amma-ray repeaters.